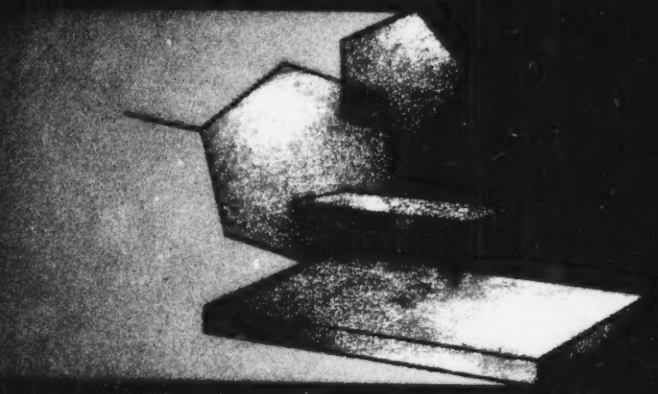
Working with Technology:
A Survey of Automation in Canada

GORDON BETCHERMAN
KATHRYN McMULLEN



ECONOMIC COUNCIL OF CANADA 1986

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Introduction

New technologies have played an important role in the transformation of the Canadian economy during the 1980s. One prominent aspect of this development concerns the employment implications of the technological changes. Despite the widespread fascination with high tech, factual information on how computers, robots, and other new technologies are affecting workers and jobs has been limited. Accordingly, the Economic Council of Canada has launched a major investigation of the labour market impacts of technological change. Slated for publication in the summer of 1987, the study examines employment and income effects of new technologies, their skill consequences, and related policy issues such as the requisite education and training. Results will be based on a wide range of research studies as well as consultation with labour, business, government, and other relevant groups.

As part of that overall project, the Council recently carried out a nation-wide survey of employers regarding their experiences with computer-based technological change. With information from close to 1,000 establishments, this effort – the Working With Technology Survey – is unique in terms of both subject and scale. In addition to cataloguing the new technologies reported by the respondents, the Survey results also describe the employment and organizational changes accompanying the technical advances. The process of introducing technological change and the human resource strategies used to meet new employment requirements receive particular attention.

In this summary report, the major findings of the Working With Technology Survey are highlighted. A more detailed analysis of the results will be published at a later date.

Highlights

- The results of the Working With Technology Survey indicate that computer-based innovations have been widely adopted by Canadian establishments. Three-quarters of the organizations surveyed reported the introduction of some computer technology during the first half of the 1980s. Particularly high rates of innovation were found in wholesale trade, communications and utilities, business services and, within manufacturing, the machinery, chemical, paper, and electrical and electronic products industries.

- Between 1980 and 1985, employment growth rates in innovating and non-innovating establishments were very similar. The new technologies introduced by the innovators resulted in some labour displacement but this was offset by the employment these establishments appear to have generated through increased sales.

- While there was a high incidence of computer-based technological change, much of the innovation reported involved relatively low-cost office technologies. Almost two-thirds of the tech changes introduced between 1980 and 1985 were office innovations such as word processing, personal computers, and office networks. Some shifts are foreseen by the respondents for the 1986-90 period when the emphasis will be redirected somewhat toward process automation systems, especially computer-aided manufacturing and design.

- Nearly three-quarters of the innovating establishments indicated that technological changes had resulted in a need for new or substantially altered vocational skills. The dominant strategy for meeting these new skill requirements was retraining existing workers. Much of this training effort, however, consisted of short duration, on-the-job programs.

- As a consequence of the dominance of office innovations, the labour impacts of high tech introduced in the 1980-85 period were focussed primarily on white-collar workers. Most of the technology-induced retraining and recruiting involved personnel in sciences and engineering, clerical, and managerial occupations. The forecasted rise in large-scale process automation should lead to greater labour adjustment, particularly in blue-collar occupations, during the last half of the decade.

Sample Description

The results of the Working With Technology Survey are based on information gathered from 946 organizations across Canada. The unit of analysis is an establishment which essentially represents operations at a single physical location. All industries, excluding agriculture, fishing, construction, and public administration, were included in the sample. The distribution of participating establishments by province and industry is shown below.

Sample Distribution by Province and Industry

Province	Per cent
Newfoundland	1.1
Prince Edward Island	0.6
Nova Scotia	2.6
New Brunswick	1.8
Quebec	27.5
Ontario	43.3
Manitoba	3.6
Saskatchewan	2.4
Alberta	6.8
British Columbia	10.0
Northwest Territories	0.2

Industry	
Primary	4.0
Manufacturing	45.3
Food, beverages, tobacco	5.1
Rubber and plastics	2.0
Leather, textiles, clothing	5.0
Wood and furniture	4.5
Paper	2.4
Printing and publishing	3.4
Primary metals	2.6
Fabricated metals	4.6
Machinery	3.1
Transportation equipment	2.9
Electrical and electronic products	3.8
Chemicals	2.8
Other manufacturing	3.2
Transportation, communication, utilities	6.8
Trade	13.5
Finance, insurance, real estate	5.1
Services	25.2
Business	7.6
Health and social	6.6
Other services	11.1

Survey Results

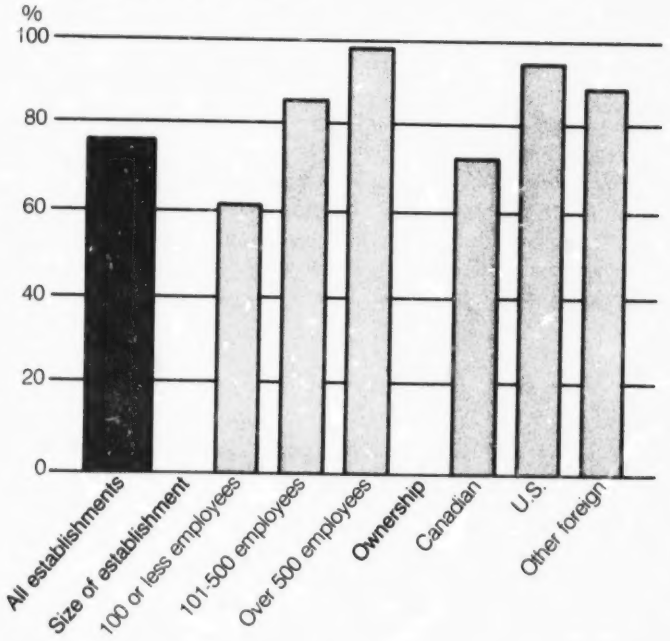
Who Are the Innovators?

There was considerable variation in the scale of new technologies reported by establishments, ranging all the way from the implementation of comprehensive factory and office automation systems to the installation of a single personal computer. Three-quarters of the Survey respondents, however, did report that they had introduced some computer-based technological change since 1980.

As might be expected, large organizations were more likely to innovate than small ones. While only 62 per cent of those with 100 or less employees introduced new technologies, virtually every establishment with more than 500 employees reported some computer-based tech change.

Establishments with foreign parent companies introduced high tech more often than those under Canadian ownership. American control had a particularly strong association with innovation as 94 per cent of these respondents reported technological changes. The comparable figure for Canadian-owned operations was 72 per cent.

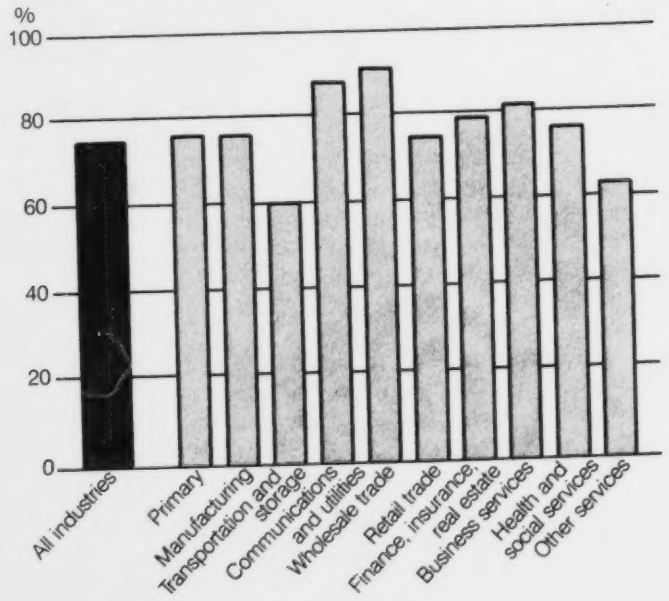
The Innovators
(percentage of establishments reporting computer-based technological change, 1980-85)



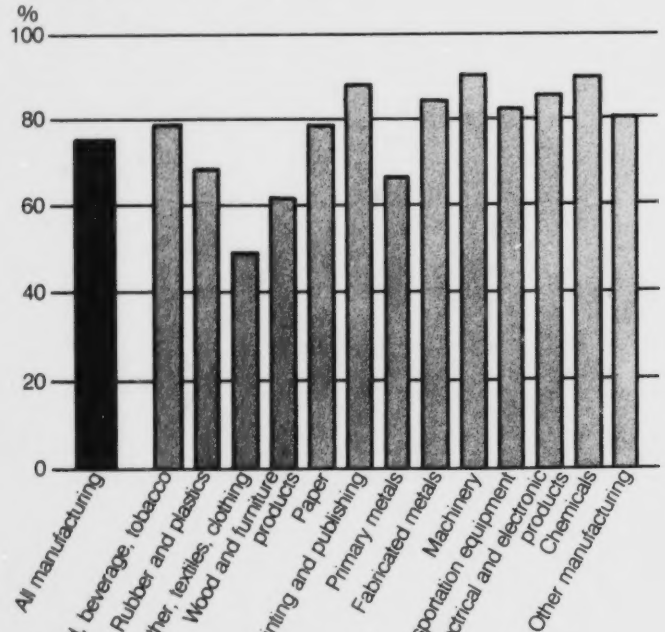
Industries and Innovators

Establishments in wholesale trade and communication and utilities were the most likely to have introduced computer-based technologies since 1980. Other industries with relatively high incidences of tech change were business services and finance, insurance, and real estate. Manufacturing establishments, representing 45 per cent of all respondents, reported innovations at a rate just above the all-industry average. Within manufacturing, however, there was considerable variation in the incidence of tech change. The introduction of computer technologies was most common in machinery, chemicals, printing and publishing, and electrical and electronic products. Details on the types of innovations in these industries are presented later.

Industries and Innovators
(percentage of establishments reporting computer-based technological change, 1980-85)



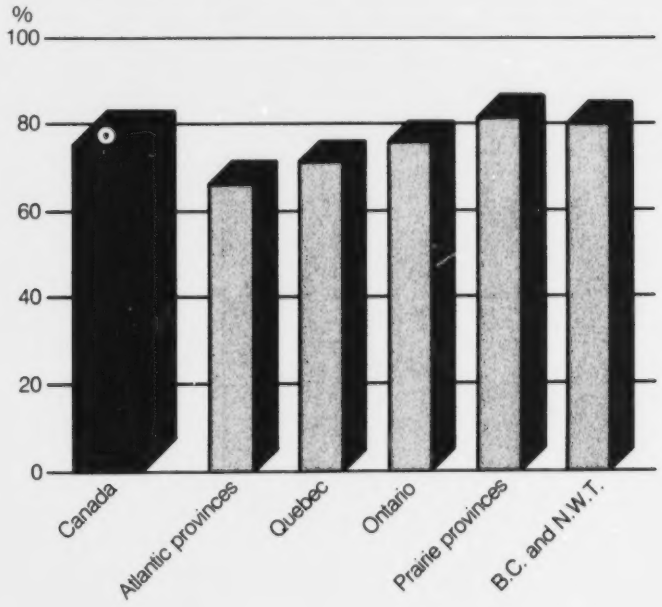
Innovators in Manufacturing
(percentage of establishments reporting computer-based technological change, 1980-85)



The Regional Dimension of Innovation

The incidence of computer-based innovation during the first half of the decade varied in different regions of the country. The proportion of establishments which introduced the new technologies increases as one moves westward. Respondents in the two western regions had the highest rates of innovation, the Atlantic provinces the lowest, with Quebec and Ontario fitting in between. Certainly, to some extent, these figures reflect the regional distribution of industries. For example, a high tech sector like business services is more likely to be located in Ontario and the West than in the Atlantic provinces. Nevertheless, there were regional differences within industries in the incidence of innovation, which suggest that geography, itself, is part of Canada's high tech story.

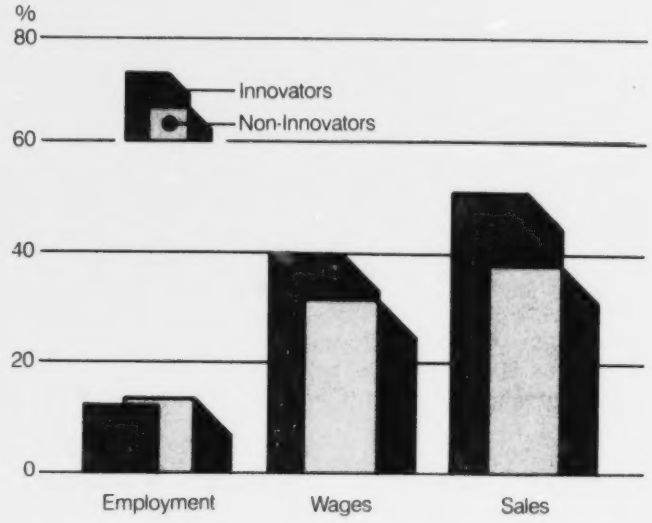
The Regional Dimension of Innovation
(percentage of establishments reporting computer-based technological change, 1980-85)



Innovators and Non-Innovators: Jobs, Wages and Sales

Between 1980 and 1985, innovating establishments grew 12 per cent in terms of the median number of full-time employees while non-innovators expanded by 13 per cent. These growth rates were comparable despite the fact that the new technologies introduced appear, for the most part, to have been labour-saving in nature. Offsetting technological displacement for the innovating establishments, however, was the employment they generated through increased volume. This increased volume is reflected in the substantially higher growth in sales for innovators compared to non-innovators. Wages, as well, were consistently higher in innovating establishments across all occupational groups in both 1980 and 1985. Wage gains were greater, too, increasing 40 per cent on average for innovators and 32 per cent for non-innovators.

Innovators and Non-Innovators: Jobs, Wages, and Sales
(percentage change in full-time employment, wages, and sales, 1980-85; based on establishment medians)

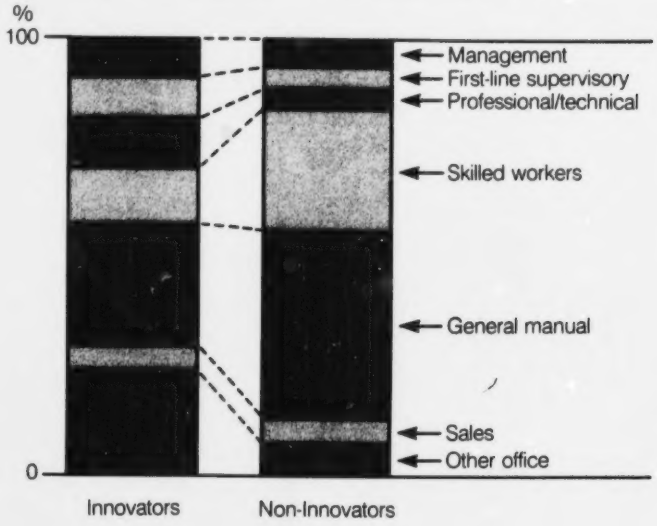


Innovators and Non-Innovators: Occupational Structure

The occupational structure of innovating establishments tends to be quite different from that of non-innovators. Managerial, supervisory, professional/technical, and office occupations accounted for twice as much employment in innovators as in non-innovators. Professional and technical and other office workers, in particular, were much more prominent in innovating establishments. On the other hand, the workforce of non-innovating establishments consisted predominantly of general manual and skilled blue-collar workers.

Such marked differences notwithstanding, both the innovators and non-innovators experienced similar shifts in occupational structure over the 1980-85 period. In both types of establishments, the professional/technical group was the fastest growing. In contrast, the employment share accounted for by general manual workers declined among innovators and non-innovators.

Occupational Structure, 1985
(percentage of employment in each occupational group)



The Technologies

The 946 Survey establishments reported 1,948 cases of computer-based technological change between 1980 and 1985. Almost two-thirds of these were office automation technologies – word processing, personal computers (PCs)/workstations, office networks, and other office applications. Another 23 per cent consisted of cases of process automation, primarily computer-assisted manufacturing (CAM) and computer-assisted design (CAD). Industry-specific applications, mostly in the service industries, accounted for the bulk of the remainder. Some shifts are foreseen for the 1986-90 period. While office automation technologies will remain dominant at 51 per cent, the emphasis will be redirected somewhat . . . process automation.

There is a trend toward increasing sophistication of the types of systems which are being introduced. This is reflected in the shift from the smaller, and as will be shown later, less expensive office automation technologies to the larger, higher cost process automation technologies. Greater sophistication is also apparent in the types of office and process automation being planned. The share of office networks – the linking of personal computers/workstations together in an interactive system to allow information exchange among users – is expected to double. Similarly, complex process automation technologies like CAM and CAD systems are expected to grow in the last half of the decade. Additional evidence comes from the number of applications of robots which, though small, is expected to more than double among Survey respondents by 1990.

The Technologies

	Introduced, 1980-85	Planned, 1986-90
	(percentage of all applications)	
I Process Automation	**22.9**	**33.5**
Automated material handling systems	3.1	4.1
Computer numerical control (CNC)	3.1	3.2
Computer-assisted manufacturing (CAM)	9.2	14.3
Computer-assisted design (CAD)	5.1	8.4
Automated inspection & quality control	2.4	3.5
II Office Automation	**64.0**	**50.6**
Word processing	17.3	9.3
Personal computers/workstations	25.3	15.4
Office networks	4.5	9.9
Office applications	16.9	16.0
III Other Automation	**13.2**	**16.0**
Transportation, communications & other utilities-specific applications	1.7	1.5
Health services-specific applications	2.0	3.0
Point-of-sale (POS)	4.7	5.7
Other applications	4.8	5.8
Total	**100.0**	**100.0**

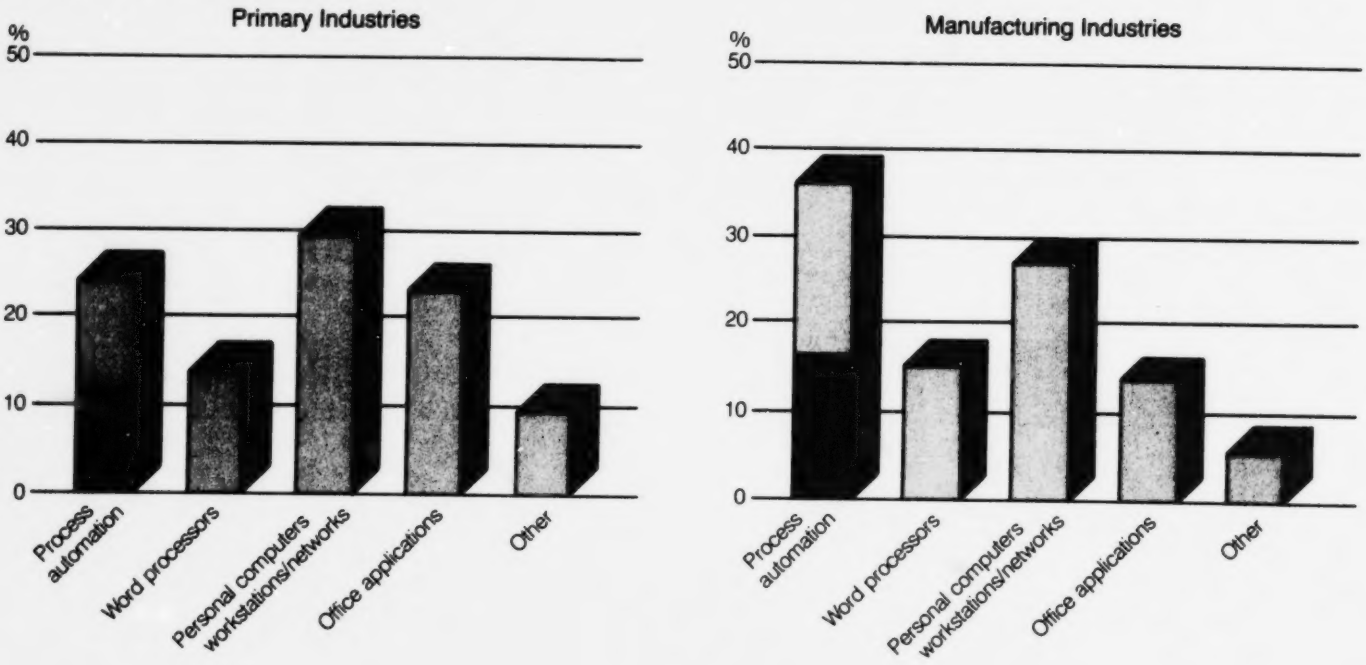
New Technologies in the Major Sectors

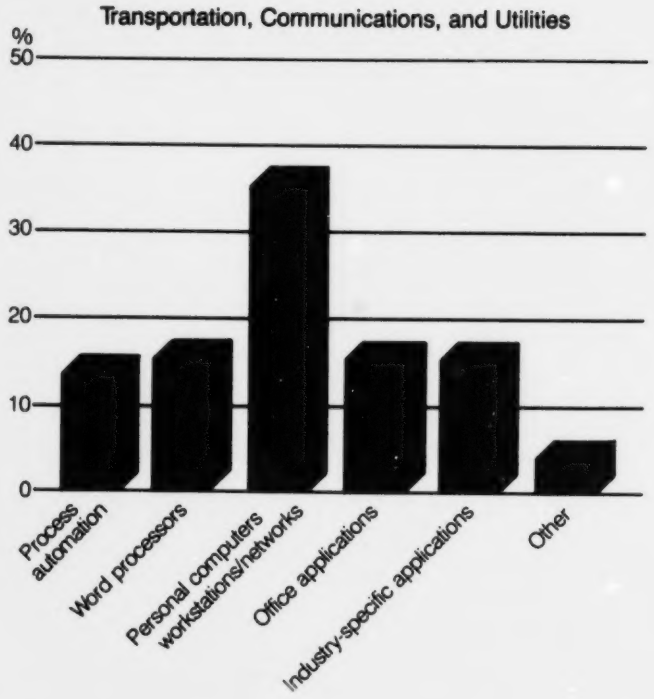
Applications of office computer systems – PCs/workstations, networks, word processing, and general office applications – dominated tech change in all industries in the 1980-85 period. This was even the case in the primary and manufacturing sectors where new office technologies accounted for 66 per cent and 56 per cent of all innovations, respectively. Not surprisingly, the dominance of office technologies was even greater in the service sector industries.

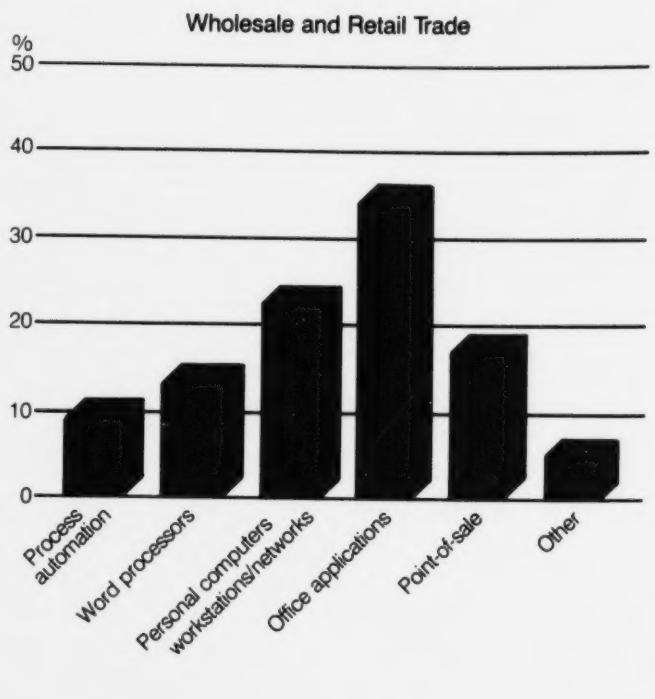
Not surprisingly, process automation – CAM, CAD, CNC, material handling systems, and quality control systems – was most common in manufacturing. Just under half of the process automation which occurred in this sector between 1980-85 consisted of CAM. Process automation was also significant in the primary industries and in the business services industry. In the former, CAM accounted for about half of the process applications while, in the latter, these consisted primarily of CAD systems.

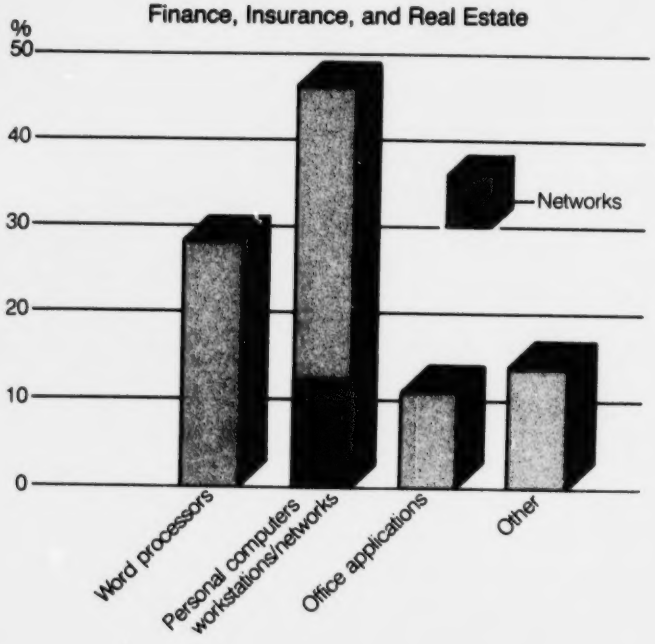
With respect to other technologies, point-of-sale applications were most evident in the accommodation and food, and wholesale and retail trade industries. Establishments in transportation, communications, and utilities reported many industry-specific applications, including computerized reservations systems, computer-assisted television broadcasting, and automated meter reading. Health and social services-specific applications include medical and material records management, drug administration, and diagnostic analysis.

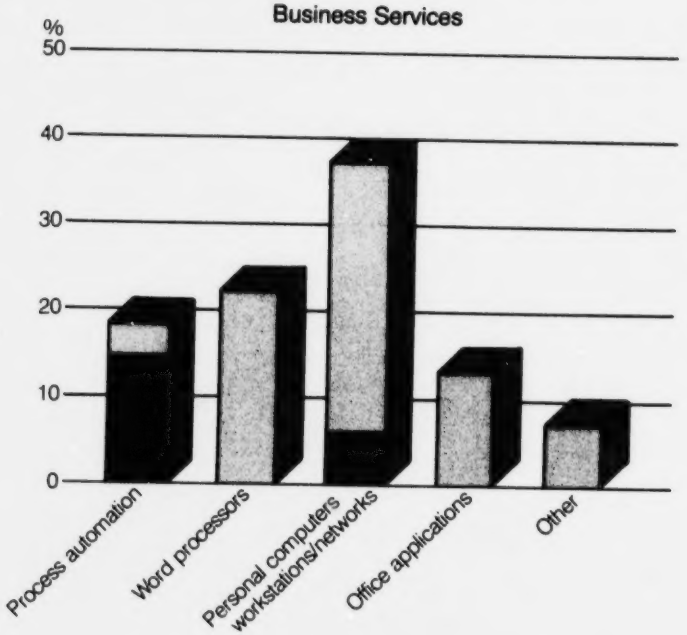
New Technologies in the Major Sectors
(percentage of all applications)

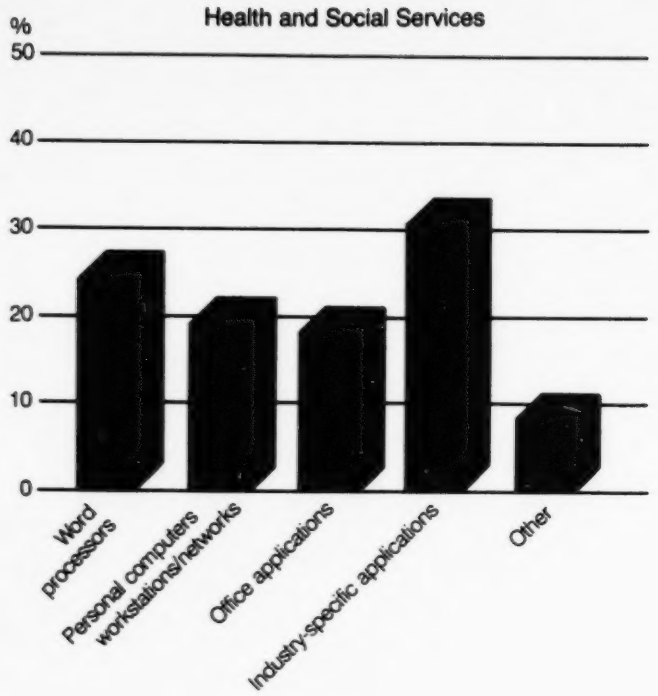



Transportation, Communications, and Utilities
%
50
40
30
20
10
0
Process automation
Word processors
Personal computers workstations/networks
Office applications
Industry-specific applications
Other


Wholesale and Retail Trade
%
50
40
30
20
10
0
Process automation
Word processors
Personal computers workstations/networks
Office applications
Point-of-sale
Other


Finance, Insurance, and Real Estate
%
50
40
30
20
10
0
Networks
Word processors
Personal computers workstations/networks
Office applications
Other


Business Services
%
50
40
30
20
10
0
Process automation
Word processors
Personal computers workstations/networks
Office applications
Other


Health and Social Services
%
50
40
30
20
10
0
Word processors
Personal computers workstations/networks
Office applications
Industry-specific applications
Other

New Technologies in Manufacturing Industries

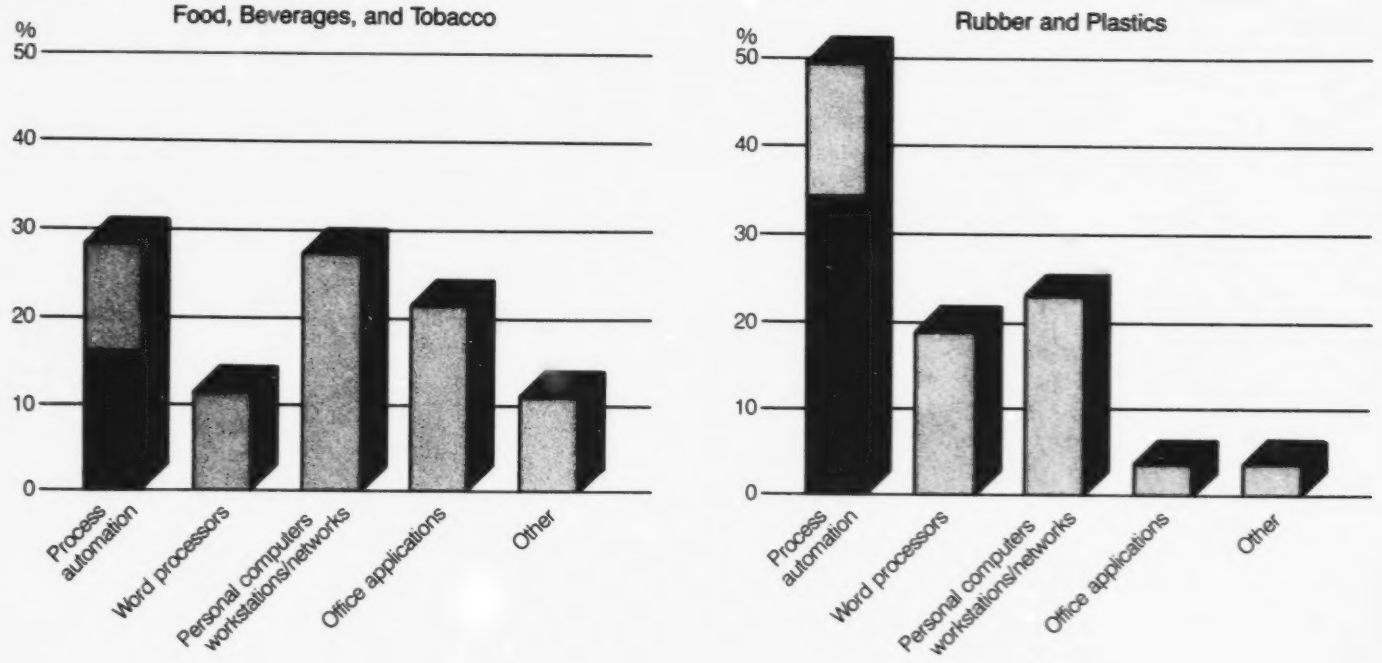
We have already noted that the majority of innovations in manufacturing were office applications, rather than process automation. Within the manufacturing sector, however, there were some differences among industries in the types of technologies introduced.

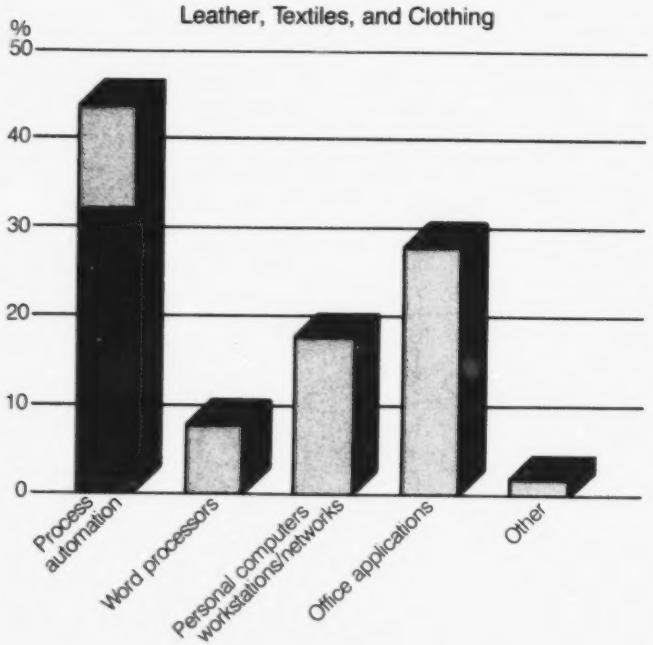
In the rubber and plastics industry, for example, one-half of the innovations were process automation technologies, well above the 37 per cent figure for manufacturing as a whole. Other industries strong on process automation were fabricated metals, machinery, leather, textiles and clothing, paper, primary metals, and transportation equipment.

Over half of the process automation technologies introduced in leather, textiles and clothing, rubber and plastics, primary metals, and paper industries were CAM applications. CNC was widely adopted only in the fabricated metals and machinery industries and CAD was notable only in electrical and electronic products. Of the small number of robot applications reported, the machinery industry accounted for the largest number of installations between 1980-85.

Process automation technologies represented only 28 per cent of the technologies introduced by establishments in food, beverages, and tobacco, and only 27 per cent of those introduced by establishments in the chemical industry. In the latter, a high percentage of employees were working with computer-based technologies in 1985. This suggests that chemicals underwent substantial automation before 1980. This is not the case for food, beverages, and tobacco where a relatively small percentage of employees were working with the technologies in 1985.

New Technologies in Manufacturing Industries
(percentage of all applications)




Leather, Textiles, and Clothing
%
50
40
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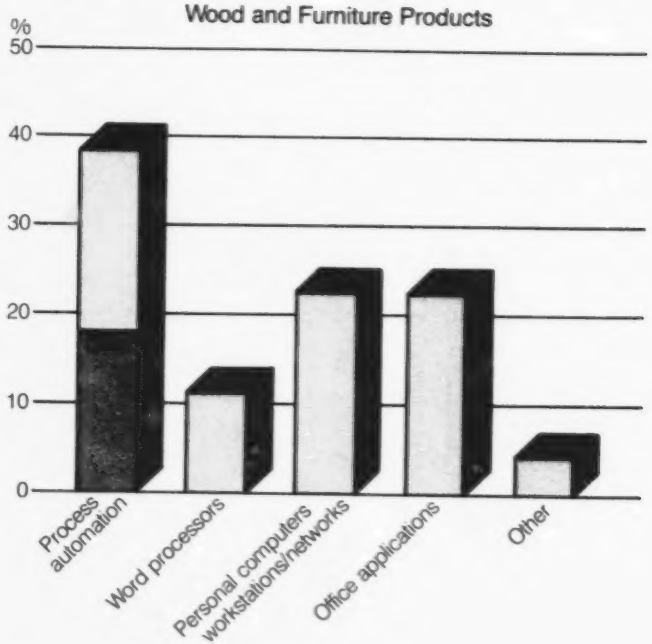
20
10
0
Process automation
Word processors
Personal computers workstations/networks
Office applications
Other


Wood and Furniture Products
%
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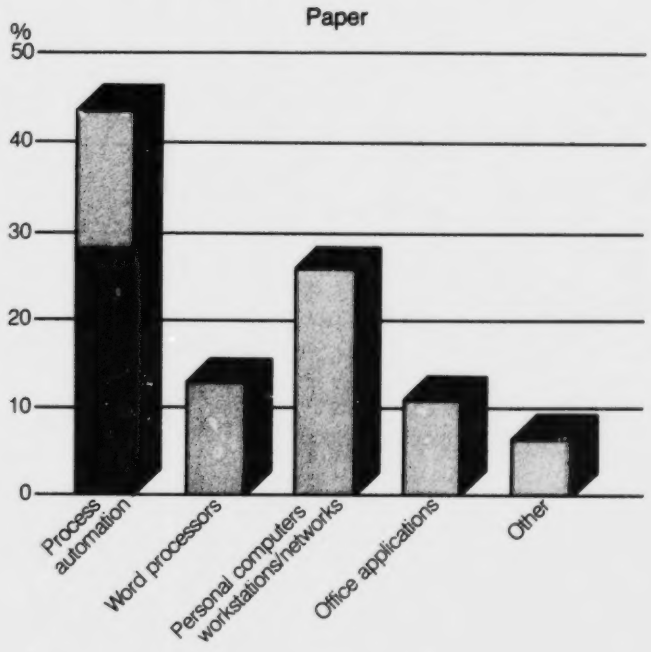
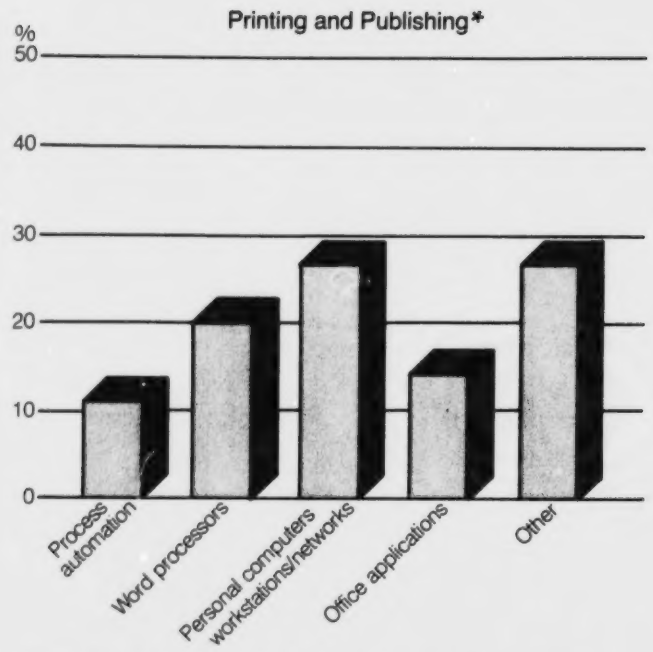
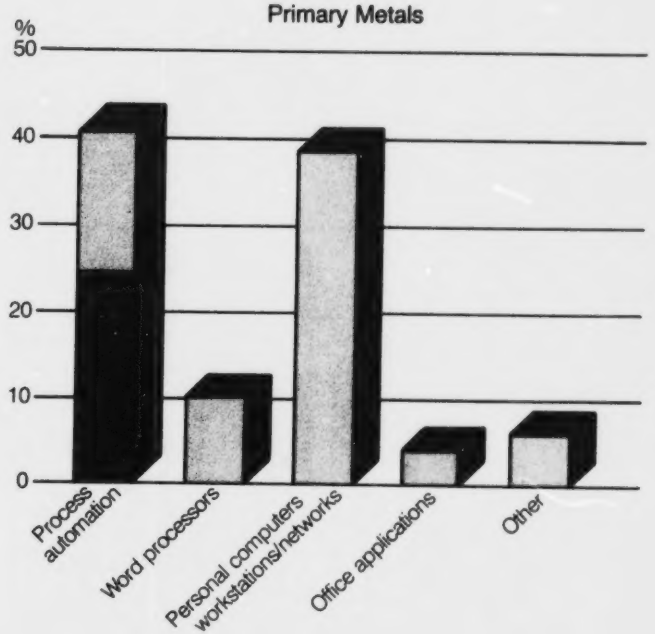
Process automation
Word processors
Personal computers workstations/networks
Office applications
Other





* Note: Process technologies with applications in many industries have been categorized as 'other'.


Primary Metals
%
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20
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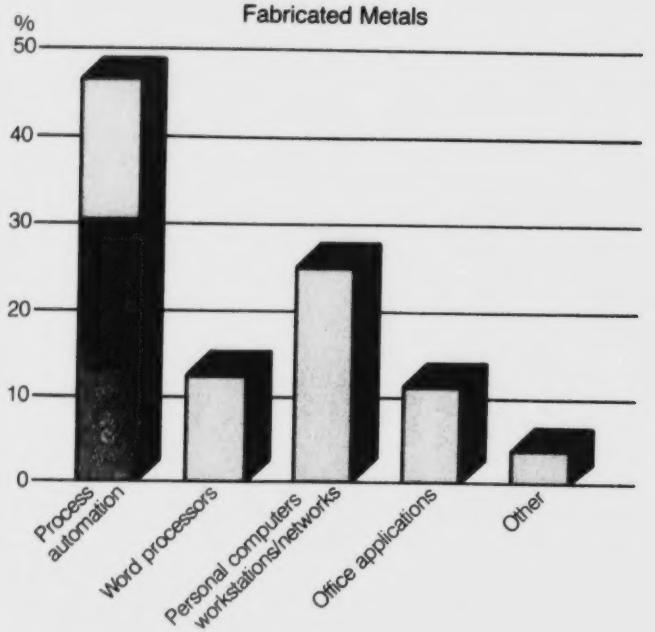
Process automation
Word processors
Personal computers workstations/networks
Office applications
Other


Fabricated Metals
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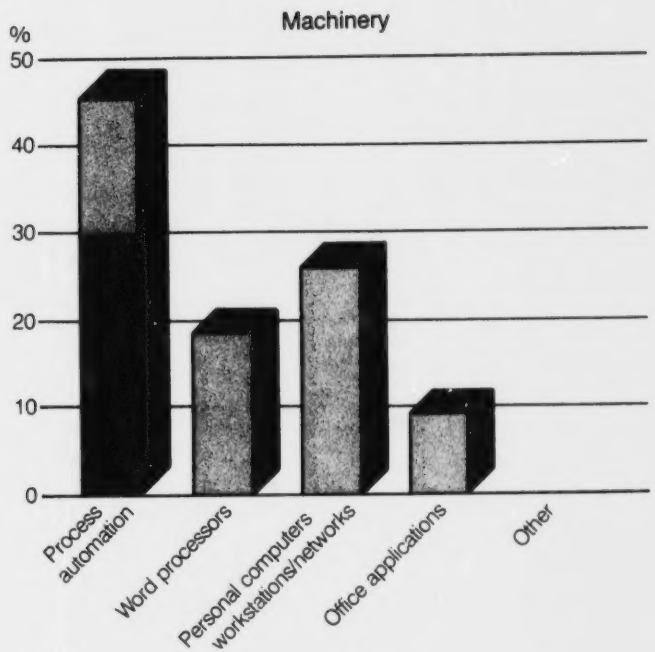
Process automation
Word processors
Personal computers workstations/networks
Office applications
Other


Machinery
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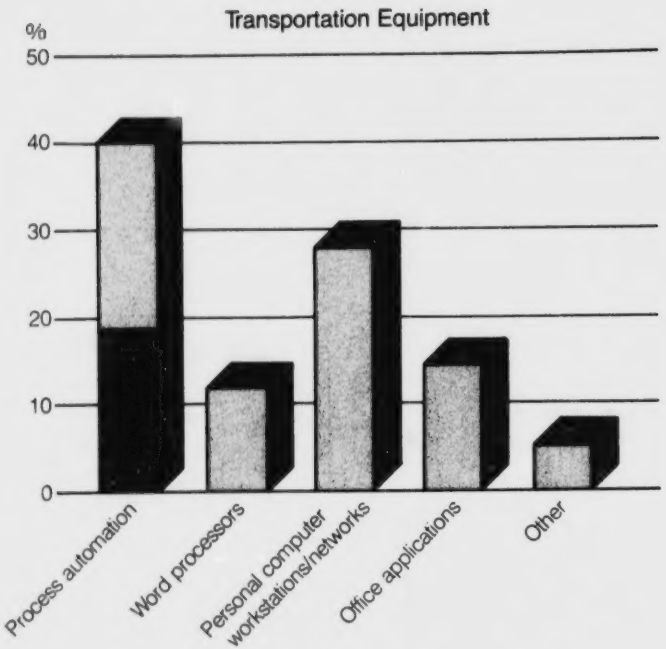
Process automation
Word processors
Personal computers workstations/networks
Office applications
Other


Transportation Equipment
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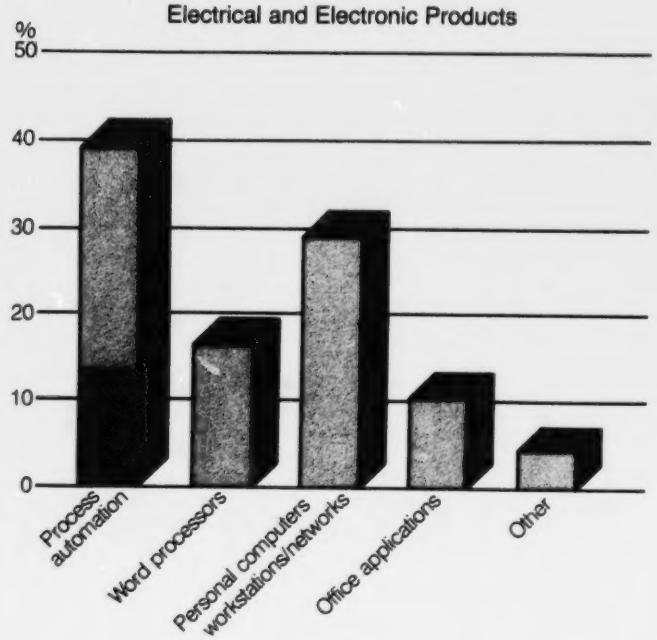
Process automation
Word processors
Personal computer workstations/networks
Office applications
Other


Electrical and Electronic Products
%
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20
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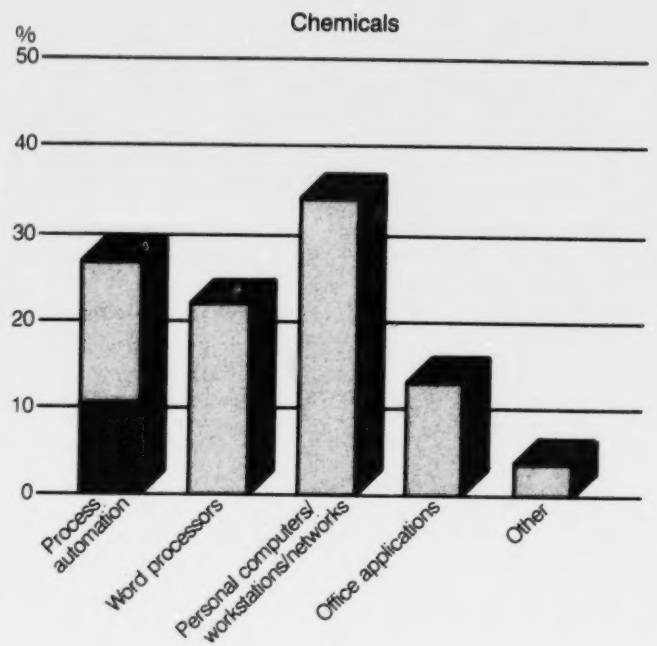
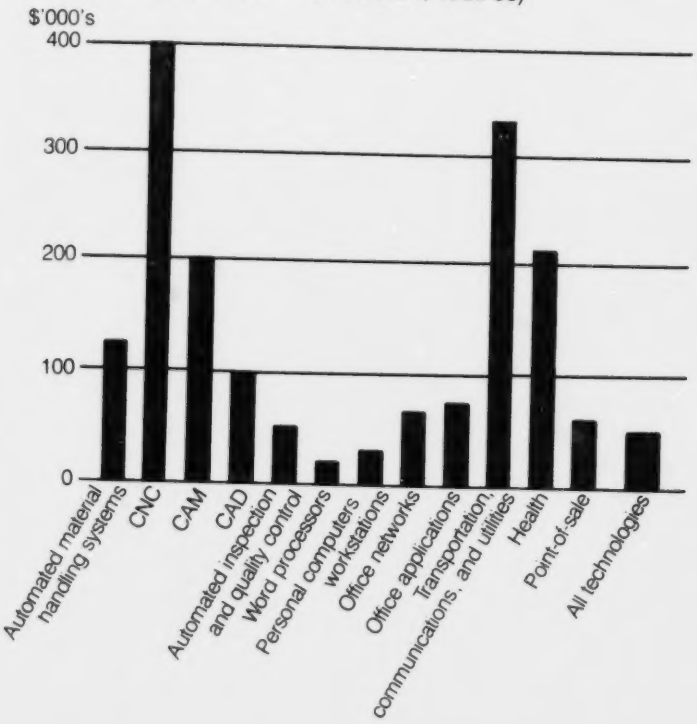
0
Process automation
Word processors
Personal computers workstations/networks
Office applications
Other


Chemicals
%
50
40
30
20
10
0
Process automation
Word processors
Personal computers/ workstations/networks
Office applications
Other

Expenditures on New Technologies

Expenditures on process automation – especially CNC and CAM – and on computer-based technologies specific to transportation and communications and health were considerably higher than for office automation. Fifty per cent of the CNC applications, for example, involved expenditures of $400,000 or more while the median figure for investments in word-processing was $20,000. Since the share of process automation is expected by respondents to increase substantially in the 1986-90 period, we can expect the scale of change to increase in future. This has implications both for the numbers and types of workers affected. Clearly, blue-collar workers can expect to encounter increasing technological change in the workplace. It is clear, as well, that the cost of the technology is a major explanatory factor associated with the patterns of technological change which we are observing. The dominance of office automation over process automation and the stronger performance of large firms compared to small firms can both be explained in large part by the cost of the technologies.

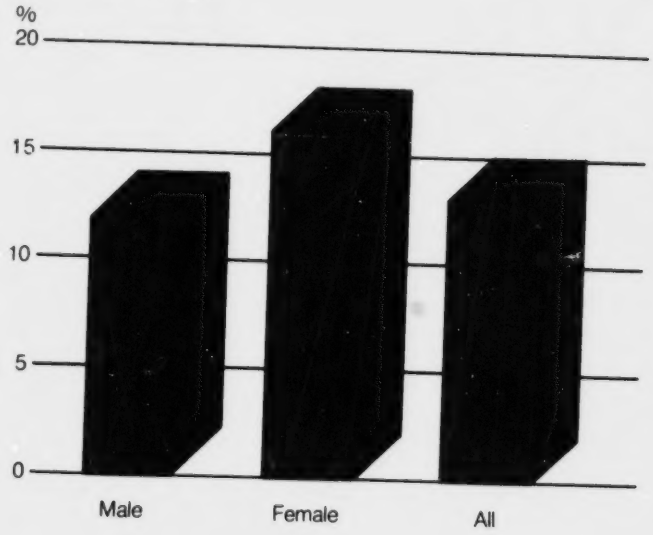
Expenditures on New Technologies
(median $000's per innovation situation, 1980-85)



Who's Working with the Technologies

Another indication of the scale of change taking place is the percentage of workers actually working with computer-based technologies in 1985. When both full-time and part-time workers are considered, we find that 13 per cent of all employees were using the technologies. However, the work being performed by women clearly was affected more than that performed by men. Close to 16 per cent of female employees were working with a computer-based system in 1985 compared to 12 per cent of male employees. This difference can be attributed partly to the industry characteristics of the innovators – most are in the service industries which traditionally employ more women – and partly to the types of technologies being put in place. The office environment, where again female employment tends to be high, has been the focus of computer-based innovation.

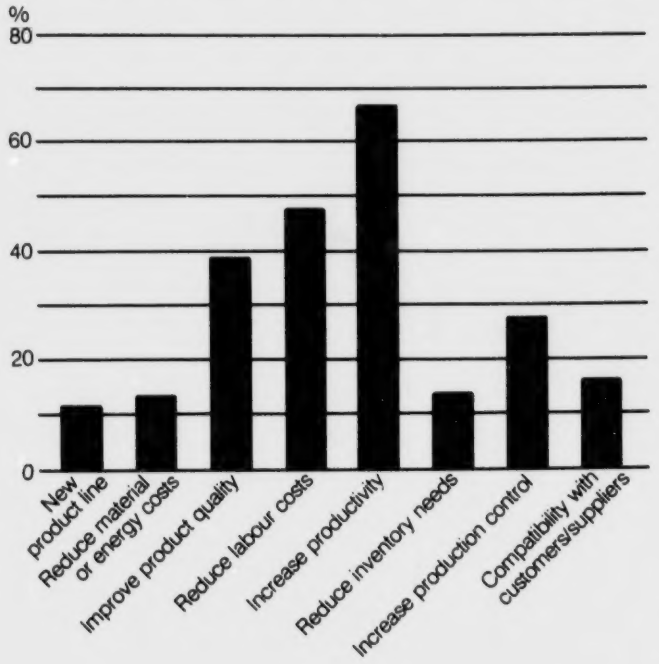
Who's Working with the New Technologies
(percentage of employees working with computer-based technologies, 1985)



Motivations for Innovating

Increasing productivity was cited as a motivation for two-thirds of the innovations reported by the Survey respondents. Less frequent, but still often identified as motivations, were reducing labour costs and improving product quality. Reasons for innovating did vary according to the type of technology. High tech in the office – particularly word processing, PCs, and networks – was driven quite simply by productivity concerns. Process automation, on the other hand, seems to have been motivated by a more complex set of factors. Certainly, productivity gains were central here as well but, in addition, some important supplementary motivators were identified. Reducing labour costs was particularly significant in the introduction of automated material handling and CNC. Improving product quality motivated the majority of innovations in automated inspection, CNC, CAM, and CAD. Both CAM and automated material handling were introduced in many cases to increase control over production. Improving product quality, raising productivity and reducing labour costs were the principal motivators for tech changes specific to transportation and communication and health. Finally, the adoption of point-of-sale terminals was driven by productivity concerns and, to a lesser extent, by the need for compatibility with customers and suppliers and, also, to reduce inventory requirements.

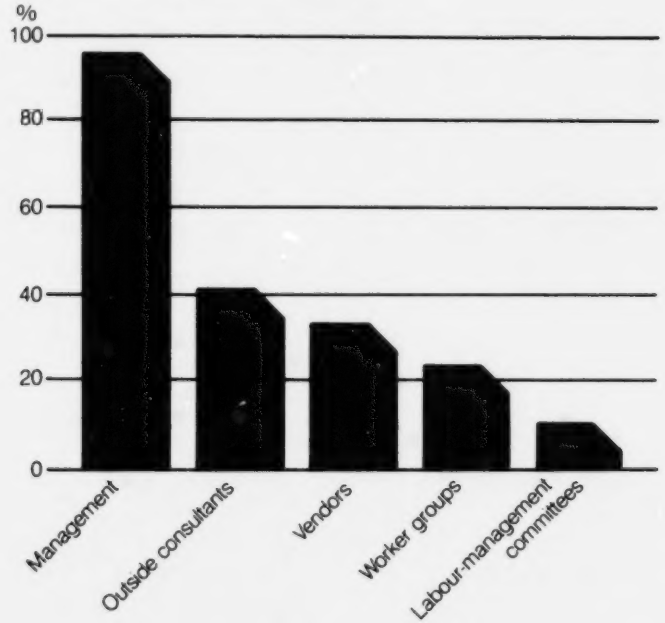
Motivations for Innovating
(percentage of innovation situations)



Planning for Tech Change

The introduction of technological change often requires considerable planning regarding technical details and, also, human resource implications. It is common practice, of course, for management to take responsibility in this area. Indeed, 96 per cent of the Survey respondents reporting tech change indicated that management had been involved in the planning. Increasingly, however, it is being suggested that innovation design might benefit from the active participation of a range of parties. According to the Survey results, other groups most commonly involved in planning were outside consultants and vendors. The participation of employees, either through worker groups or joint labour-management committees, was less frequently reported. Consultants, vendors, and worker groups were more likely to join management in planning for innovation in large establishments.

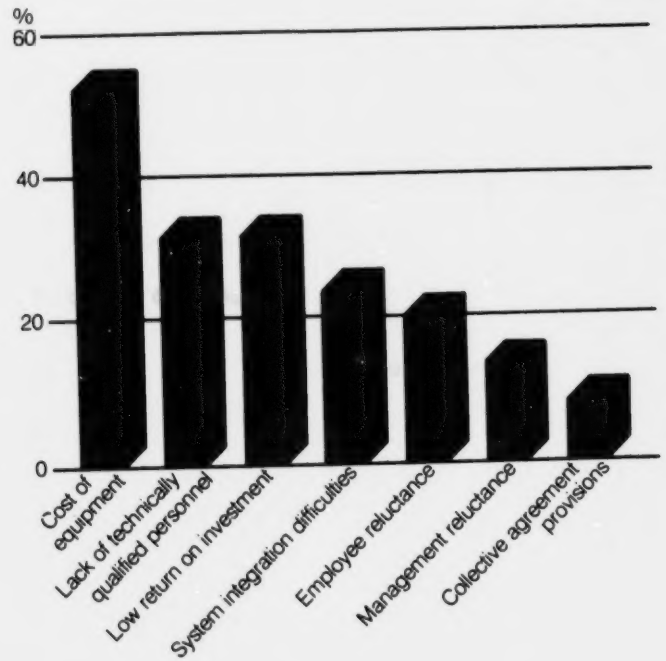
Planning for Tech Change
(actively involved in tech change planning as a percentage of all innovating establishments)



Obstacles to Innovation

Just over half of the Survey establishments identified the cost of equipment as an obstacle to introducing technological change. This finding further emphasizes the role that cost plays in explaining the relatively low incidence of the expensive process technologies in the types of innovations made. Following the cost of equipment, a lack of technically qualified personnel and a low or uncertain return on investment were the most often reported barriers to tech change. It is interesting to note that the Survey offers little evidence for the position sometimes expressed that reluctance on the part of workers or managers frequently impedes innovation. Restrictive collective agreements are another commonly perceived barrier. This view, as well, is not supported by our results.

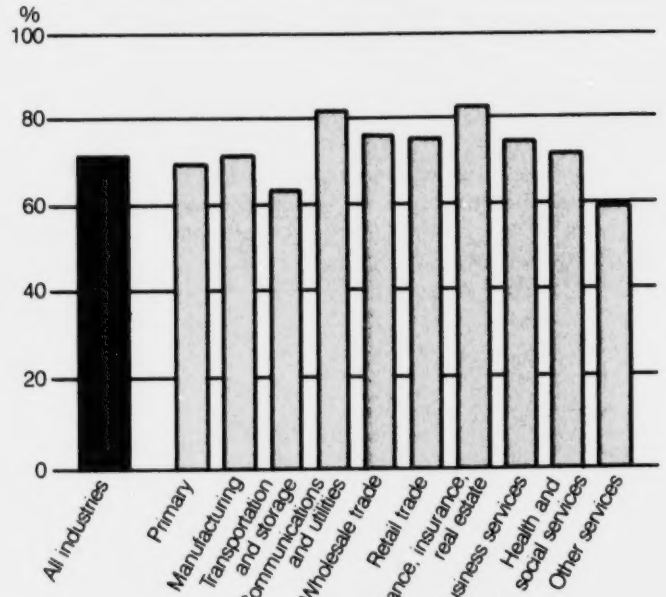
Obstacles to Innovation
(percentage of establishments reporting obstacle)



Innovation and New Skills

Among the respondents introducing technological change, 72 per cent indicated that the new technologies had led to the creation of new types of jobs or the substantial modification of existing ones. In some sectors – specifically, finance, insurance and real estate, communications and utilities, and the paper, printing and publishing, machinery, and chemical manufacturing industries – over 80 per cent of the sample reported some change in jobs. In all industries, the likelihood that tech change had affected the structure of jobs was higher in large establishments. Presumably, this reflects the greater scale of innovation reported by these respondents.

Innovation and New Skills
(percentage of innovating establishments where tech change altered jobs)



Meeting New Skill Requirements

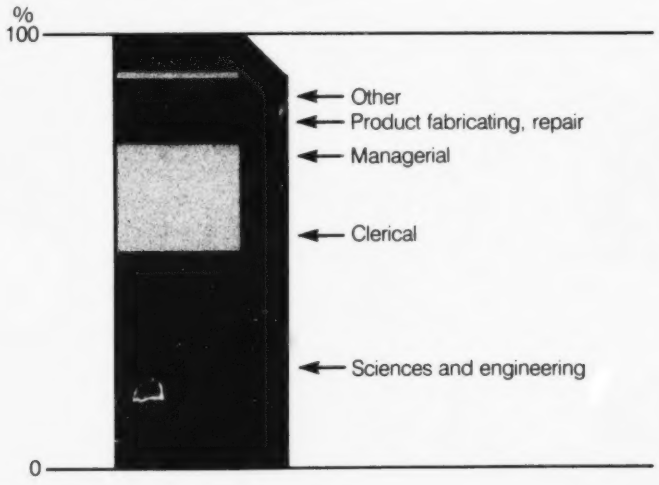
When tech change creates new types of jobs or alters existing ones, the establishment's skill requirements change. The new vocational needs can be met by recruiting outside the firm or by retraining present employees. The latter strategy predominated among the Survey respondents. Close to 95 per cent of the establishments responded to altered skill requirements by carrying out some retraining. In about one-third of these cases, some external recruiting accompanied the retraining. While retraining was virtually a universal human resources response to tech change, recruiting was prevalent only in very large establishments and in the business services and primary industries.

Meeting New Skill Requirements
(percentage of innovating establishments adopting strategy)

Occupations Recruited for the New Technologies

When Survey respondents did recruit externally to meet new skill requirements stemming from tech change, they were looking, for the most part, for highly qualified personnel. Just under half of the recruiting cases involved the sciences and engineering occupational group. In greatest demand were computer programmers and systems analysts and, to a considerably lesser degree, engineering technologists and electrical engineers. While new requirements for clerical skills were met largely through retraining existing personnel, some recruiting for this occupational category was reported, particularly for data processing clerks and word processing operators. The other major occupation targeted for external hiring was the managerial group with most of the attention here focussed on engineering managers with responsibility for computer systems. Not surprisingly, given the dominance of office innovations in the Survey results, there were very few cases of recruiting production workers in response to the introduction of the new technologies.

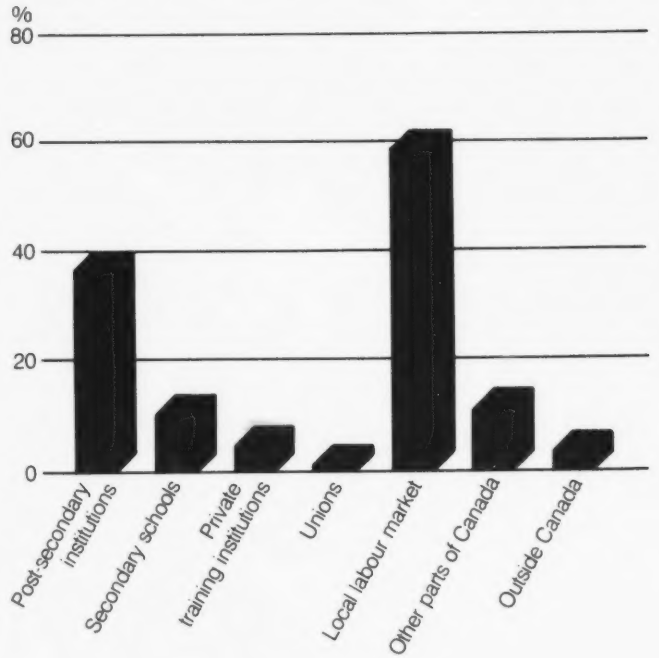
Occupations Recruited for the New Technologies
(percentage of all recruitment cases)



Sources for Recruiting

In general, most recruiting takes place in the local labour market. Indeed, this source was cited by a majority of Survey respondents using external hiring to meet skill requirements resulting from tech change. Hiring through post-secondary educational institutions was also important. Colleges and universities, in fact, were identified as the source in about half of the recruiting cases involving sciences and engineering personnel. For the most part, vocational needs induced by tech change did not lead to employee recruiting beyond the local labour market. Search that did take place elsewhere in Canada or outside the country was almost exclusively directed toward the managerial and sciences and engineering occupations.

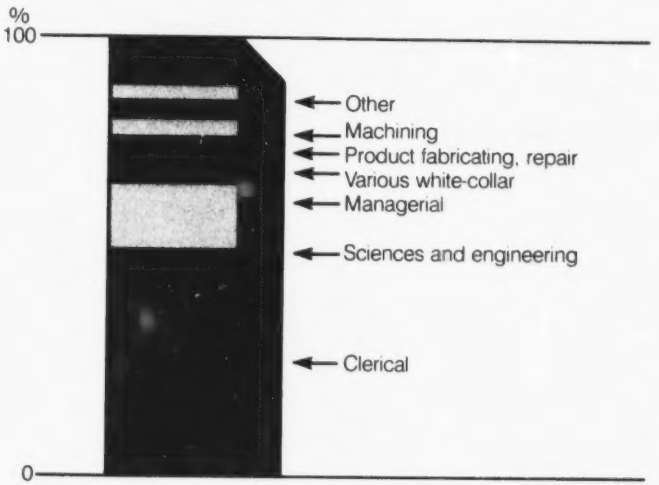
Sources for Recruiting
(percentage of all recruitment cases)



Occupations Retrained for the New Technologies

The skill effects of the new technologies introduced by the Survey respondents centered primarily on white-collar employees. Just as innovation-induced recruiting was targeted to these types of workers, so, too, was retraining. Nearly 85 per cent of the programs established in response to tech change trained white-collar personnel. While recruiting was directed primarily toward highly qualified science and engineering workers, about half of the retraining effort involved clerical occupations. Data processing and word processing accounted for the majority of the clerical training programs. The sciences and engineering and managerial occupations, together, received about one-quarter of all the technology-related retraining reported. Within these groups, programs were provided most often for computer programmers and systems analysts, draughters, engineering technologists, and financial officers.

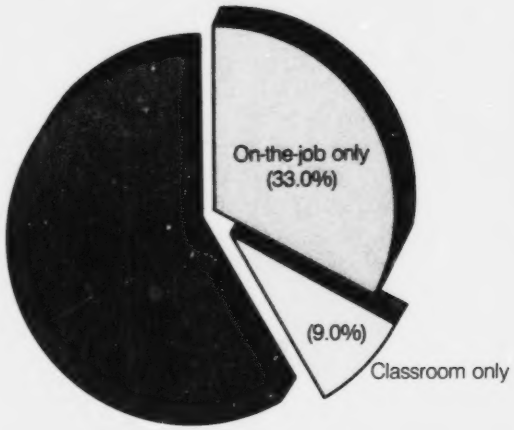
Occupations Retrained for the New Technologies
(percentage of all training programs)



Types of Training Programs

While technological change was frequently accompanied by retraining, much of this effort consisted of relatively short duration on-the-job training. Over 90 per cent of the programs carried out included on-the-job training, either alone or in conjunction with classroom instruction. There were some differences in the method of skill development, depending on the occupation being trained. While programs for clerical personnel were characteristically undertaken on the job, retraining for the sciences and engineering, product fabricating and repair, and machining groups often had a classroom component as well. For all occupations, both on-the-job and classroom training tended to be short-term. Indeed, one-half of the former type of program and over 80 per cent of the latter lasted four weeks or less.

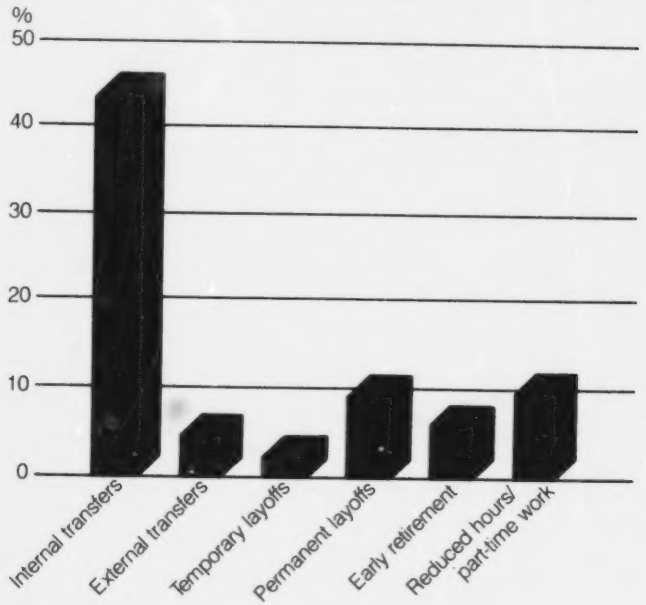
Types of Training Programs
(percentage of all training programs)



Other Adjustments to Tech Change

While recruitment and retraining are appropriate strategies when new skill requirements are created by the new technologies, other adjustments, particularly to deal with reduced numbers of jobs, are also required. By far, the most common of these adjustments was the transfer of personnel to other parts of the organization. Other adjustments were mentioned less frequently, the most often cited being reduced hours/part-time work and permanent layoffs. The smallest firms reported using these alternative adjustments rarely. Large firms, on the other hand, used a wide variety of them. The incidence of layoffs, early retirement, and reduced hours/part-time work was slightly higher in unionized establishments than in non-unionized ones.

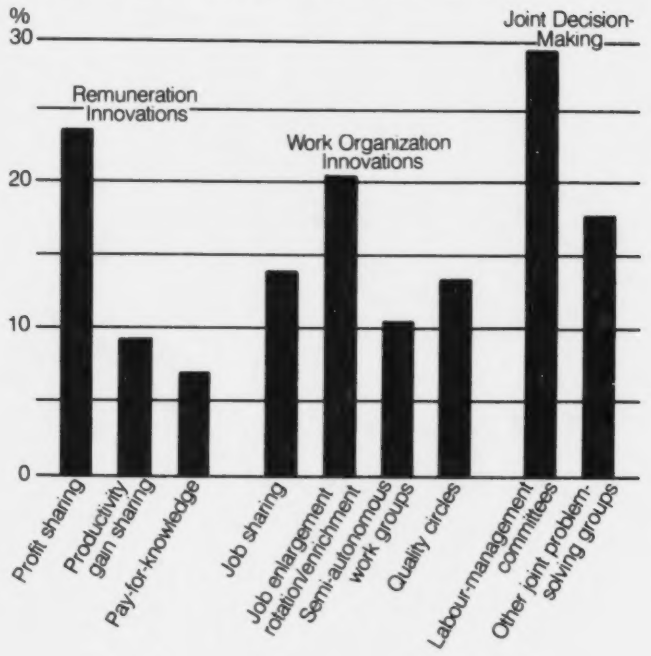
Other Adjustments to Tech Change
(percentage of innovating establishments adopting strategy)



Organizational Innovation

Technological innovation often is related to organizational innovation – new forms of decision making, work organization, and remuneration. Indeed, according to the Survey results, technological innovators did introduce organizational innovations more often than non-innovators. Joint decision-making groups, in particular, labour-management committees, were the most common form of innovative organizational arrangement. Among work organization innovations, job enlargement/rotation/enrichment was reported most frequently. Despite the attention given to quality circles and semi-autonomous work groups in discussions of organizational innovation, these are still fairly scarce. The most common form of remuneration innovation was profit-sharing, though in many cases, it was confined to management. The effect of the presence of a union differs depending on the type of work arrangement. Unionized establishments were more likely to have labour-management committees, quality circles, and other joint problem-sharing groups, but less likely to have profit-sharing, productivity gain-sharing, and semi-autonomous work groups.

Organizational Innovations
(percentage of establishments reporting programs)



Negotiating Tech Change

In union settings, negotiations over the introduction and effects of new technologies can be an important element of the innovation story. Just under half of the Survey respondents had employees covered by collective bargaining. Of these, 46 per cent reported that there had been union contract negotiations over tech change since 1980. The Survey results suggest that the bargaining concerns associated with innovation vary considerably in different situations. While a wide range of issues were raised, no single one was pervasive. The technology-related item most frequently negotiated was advance notice, followed by training, wage rates, job/income security, seniority provisions, and joint consultation. For most issues, negotiations led to contract changes just over 50 per cent of the time. Where information was the concern – layoff notice and advance notice – this figure was slightly higher. On the other hand, contract amendments were less frequent where changes in decision making – either through joint consultation or management rights provisions – was the subject of negotiations.

Negotiating Tech Change
(percentage of unionized establishments)